RESEARCH DEPARTMENT

TEMPORAL VARIATION OF THE GROUND-WAVE FIELD STRENGTH OF MEDIUM FREQUENCY BROADCASTING TRANSMITTERS

Report No. K-119

(1956/37)

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SUMMARY

This report surveys the results of measurements made by the B.B.C. Research Department and comments on earlier work by others. It is concluded that the effect, which is due apparently to a variety of factors not yet fully investigated, is no longer of significant importance in broadcasting.

1. INTRODUCTION.

Over a period of many years it has been observed that seasonal changes occurred in the field strength received from medium wave transmitters in the outer parts of their service areas. The observations discussed in this report were made to examine the degree of the variations and, if possible, to determine their cause.

2. GENERAL.

In 1927, when broadcasting was confined to the long and medium wave bands, R.H. Barfield[1] made a series of measurements of the field intensity of the London broadcasting station 2LO, operating on 825 kc/s, to determine the attenuation of wireless waves over land. The apparent conductivity of the earth derived from these measurements was in all cases lower than the conductivity expected from the results of an earlier experiment by the wave tilt method, and Barfield concluded that the difference was due to the absorption of energy by trees. To verify his theory, he measured the apparent bearing of the transmitting station in the neighbourhood of a tree, and from the error in bearing calculated the distortion in the magnetic component of the transmitted wave which enabled him to derive the power absorbed by the tree. Barfield suggested that the surface conductivity of the earth was dependent on two factors, the conductivity of the ground, and the number of trees per unit area standing on the surface. He noted that measurements made in winter and in summer showed that the absorption by trees was greater in the summer.

Gerber and Werthmüller[2], working in Switzerland, based a comprehensive series of observations on Barfield's theory. They investigated the conductivity of different types of trees, both in summer and in winter, by measuring the currents in them with the aid of a search coil. The conclusion they reached is that the sap in trees behaves as a conductor, and that the conductivity of a tree is dependent on the amount of sap present, and on its temperature. They explained the seasonal variation in the ground-wave field by the annual cycle of change occurring in trees. Winter and summer measurements on the Berne transmitter (1375 kc/s) taken along a 5 km radial through a wood were recorded in a graph. The summer curve has the steeper

slope, demonstrating the greater rate of attenuation in that season; at the end of this short run it is 10 dB below the winter curve.

These investigators carried out a further experiment[3] on 764 kc/s, in which the variations over forest land were compared with those over open country. The effect of changes in atmospheric temperature in the presence of trees is well illustrated in the figures which accompanied their report.

The possibility of other mechanisms contributing to the seasonal change in the ground-wave field was considered both by Gerber and Werthmüller and by other workers. For instance, Friend and Colwell[4], working on frequencies between 1500 and 3500 kc/s, showed that tropospheric reflections occur at air-mass boundaries and other similar discontinuities. They found that that height of the reflecting layer is generally less than 2 km, and the reflection coefficients are of the order of 10^{-3} to 10^{-5}.

Gracely[5] examined statistically data collected in America over 6 paths over the frequency range 640 to 1170 kc/s. His conclusion was that the variations in signal strength for the cases examined are more closely and continuously correlated with temperature than with any other single type of meteorological data. Gracely's results were assembled in the form of a nomographic chart to which reference will be made later in this report.

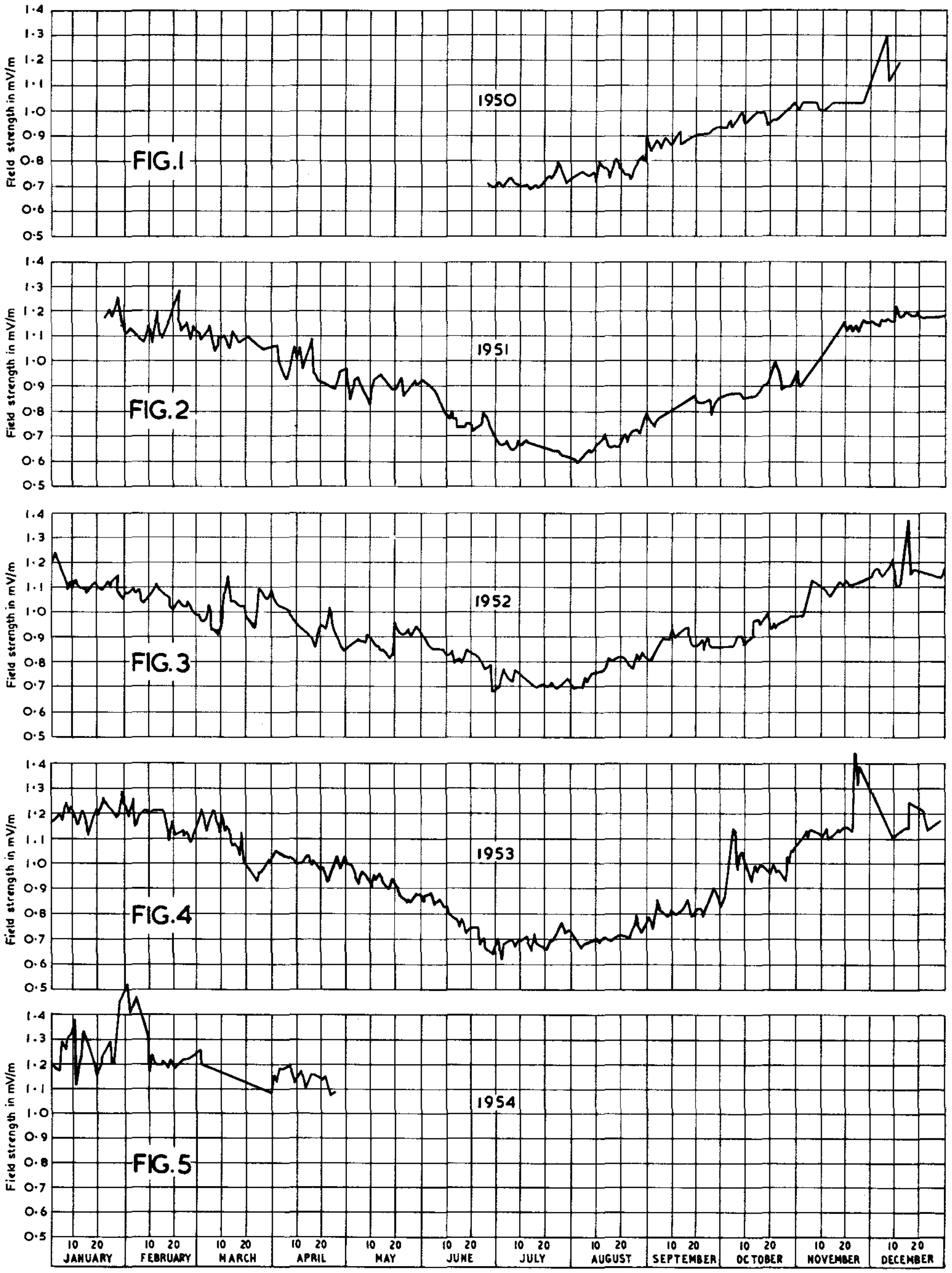
3. B.B.C. MEASUREMENTS.

Measurements of the noon field strength of the Droitwich transmitter radiating on a frequency of 1088 kc/s have been made at Kingswood in Surrey[6]. Figs. 1 to 5 are a plot of the measurements, taken continuously over a number of years. The annual cycle of change is clearly seen, and is in the ratio 2:1. There are besides small day-to-day fluctuations in signal strength of the order of 10 or 15%.

A parallel set of measurements of the Norwegian transmitters and Stavanger and Vigra were taken at Edinburgh[7]. The maximum variation in signal strength over the long sea path was about 10%, much smaller than that recorded over the much shorter land path. The difference indicates clearly that the annual cycle is associated with the presence of land.

The day-to-day fluctuations over the Droitwich-Kingswood path showed very close correlation with the weather. Increases in signal strength always occurred in anticyclonic conditions, and this aspect of the variations was investigated theoretically with the aid of a formula furnished by Saxton[8] in another context. Calculations made from data published in the aerological reports gave values of reflection coefficient at the troposphere around 10^{-2}, the height of the reflecting layer being in general about 800 metres. These values are in reasonably good agreement with those of Friend and Colwell. The fluctuations in signal strength derived from them accord very well with recorded variations.

Using Gracely's nomographic chart, a calculation for the Droitwich-Kingswood experiment for two temperatures, 39°F to represent the mean for winter, and 64°F, the summer mean, gave an expected difference in signal strength in the two seasons of only 17%. This is much smaller, however, than the annual variation actually observed over the Droitwich-Kingswood path.



Figs. 1-5 - Temporal variation of ground-wave field strengths.

Variations of noon field strength from Droitwich, 1088 kc/s, at Kingswood Warren, Surrey, during 1950 - 1954 inclusive. Distance 109 miles (175 kilometres).

4. CONCLUSIONS.

The conclusions to be derived from this survey are:

i. There is strong evidence that the variations in the intensity of the ground-wave field at medium frequencies result from the lesser or greater absorption by trees of the energy in the radiated wave. However, on a path such as Droitwich-Kingswood the tree density, in the form of woods, is not particularly high and it is possible that some other factors contribute to the effect.

ii. Secondary variations of much smaller magnitude are brought about by meteorological changes in the troposphere.

Although it would seem desirable to continue the studies in order to obtain a better understanding of the cause of these temporal variations, we are of the opinion (recently endorsed by the C.C.I.R. VIIIth Plenary Assembly at Warsaw) that the practical importance is not now very great in view of the deterioration of medium wave service areas due to the present congestion of the band. It is therefore proposed to abandon further study of the phenomenon at present.

5. REFERENCES.

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7. Addendum 1 to (6).

8. Saxton, J.A., "The Propagation of Metre Radio Waves Beyond the Normal Horizon, Part I", Proc. I.E.E., Vol. 98, Part III, No. 55, September 1951.

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